Biopiles

Biopiles – Overview

- Introduction
- Treatability Studies
- System Design & Construction
- System Operation & Maintenance
- Video
- Case Histories
- Questions & Answers

Biopiles – Introduction

A solid-phase, ex-situ process, using forced aeration to increase oxygen availability to accelerate contamination degradation

Biopiles – Introduction

- Indigenous microorganisms
- Contaminants reduced to CO_2 and H_2O
- Basic construction
  - Treatment pad
  - Aeration system
  - Irrigation/Nutrient system
  - Leachate collection system
- Remediation costs range from $25 to $70 per ton

Biopiles – Applicability

- Heavy-chain hydrocarbon (JP-5 and diesel)
- Contaminated soil sources:
  - UST removal
  - Spill sites
  - Pipeline leaks
- Treatment time typically 3 - 6 months

Biopiles


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Biopile Technology Selection Decision Tree
Soil Contaminated with Petroleum Hydrocarbons?
No
Evaluate Appropriate Remedial Alternatives
Yes
Define Extent of Soil Contamination
• Volume
• Site Assessment Data
Soil is or will be Excavated?
No
Natural Attenuation as a Feasible Alternative?
No
Contamination Limited to Shallow Vadose Zone (depth ≤ 8 feet)?
No
Yes
Yes
Yes
Follow Protocol for Natural Attenuation
Excavation is Feasible?
No
Yes
Yes
Total < 250 CubicYards of Soil?
Plan for Soil Excavation and Aboveground Treatment or Land Disposal
Yes
Site Cleanup is Time-Sensitive ~ 1 Year?
No
Evaluate In Situ Remediation Options
No
Offsite Disposal More Economical?
No
Total Soil Volume per 3-Month Time > 3,000 Cubic Yards or Available Land is Limited?
Yes
Evaluate Biopile Economics and Technical Feasibility vs. Low-Temperature Thermal Desorption or Other Alternative
Yes
No
Select Alternative Treatment Technology
• Asphalt Blending
• Thermal Desorption
• Landfill
Selection Criteria
• TPH ≤ 50,000 mg/kg
• Heterotrophic Bacteria ≥ 1,000 CFU/1g Dry Soil
• pH @ 6 to 9
• Water @ 70 to 95% of Field Capacity
• Low Clay or Silt Content (Soil Void Volume ≥ 25%)
• C:N:P:K Near 100:15:1:1
• Toxic Metals ≤ 2,500 mg/kg
Yes
Biopile Feasible?
No
Select Alternative Treatment Technology
Conduct Treatability Study
No
Selection Criteria Known and Met?
Yes
Recommend Adjustments
• Blend Organic Bulking Agents
• Add Water
• Adjust pH
• Shred Soil
• Adjust pH
• Adjust C:N:P:K
• Consider Climate Extremes
Adjusted Soil Matrix Can Cost-Effectively Meet Selection Criteria?
Yes
Site is Expected to Operate ≥ 5 Years?
Yes
Permanent Biopile Facility
No
No
Select Alternative Treatment Technology
Temporary Biopile Facility
Plan and Construct Biopile Using Treatability Study Results for Design Basis
TEKTREEa.CDR

Biopiles – Treatability Studies

Purpose

- Determine if contamination can be degraded to acceptable cleanup levels by indigenous microorganisms
- Establish soil conditions in the soil environment that enhance the health of the fuel-degrading microorganisms

Biopiles – Treatability Studies

Information Desired

- Residual hydrocarbon contaminant concentrations/types
- Hydrocarbon-degrading microorganism population density
- Physical/chemical parameters: pH, nitrogen, phosphorus, moisture, salinity, particle size distribution
- Acceleration of biodegradation with the application of H_2O, nitrogen, phosphorous
- Biodegradation rate: 6-8-week soil column study

Biopiles – Treatability Studies

Standardized Laboratory Methods Used

- Bacteria counts
- Nutrient needs
- Hydrocarbon analysis
- Microbial respiration
- Others

Biopiles – Treatability Studies

Costs

- $8,000 - 10,000 average
- Cost can range up to $20,000 if different soil matrices are tested

Biopiles

Technology Transfer Documents

- Biopile Treatability Studies - Technical Data Sheet TDS-2024-ENV March 96
- Biopile Design and Construction Manual - Technical Memorandum TM-2189-ENV June 96
- Biopile Operations and Maintenance Manual - Technical Memorandum TM2190-ENV June 96

Biopiles

Biopile Design and Construction Manual (TM-ENV-2189)

- Details selection procedures and design steps
- Uses a 500- to 750-yd^3 design as an example case
- This manual contains:
  - Biopile decision tree
  - Technology overview
  - Permitting strategy
  - Predesign activities
  - Description of temporary and permanent biopile construction
  - 11 appendices listing reference information and sample calculations

Biopiles

Biopile Operations and Maintenance Manual (TM-2190-ENV)

- Companion document to the Biopile Design and Construction Manual
- Provides step-by-step operational guidance
- Main text includes:
  - Technology overview
  - Sampling and analysis
  - Regulatory issues
  - System operation
  - Health and safety
- Appendices contain:
  - 10 O&M checklists and data sheets
  - Sample calculations
  - Troubleshooting guide
  - General health and safety plan

Biopiles

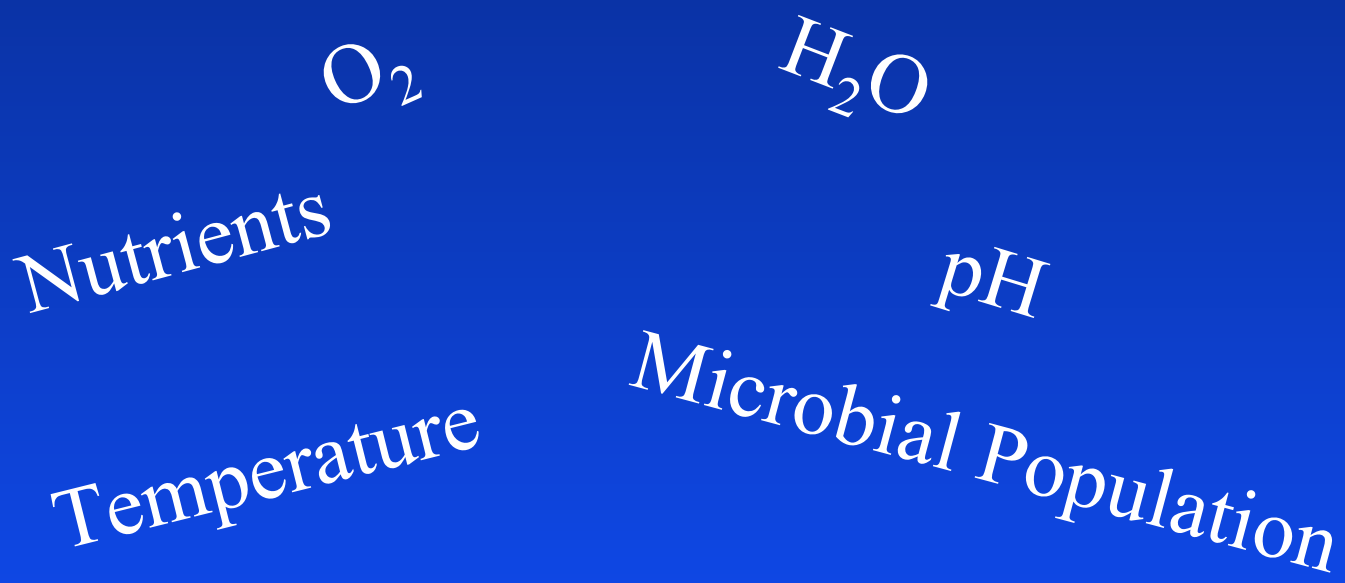
Biopile Cost Estimator

- Software package written in MS Excel Visual Basic
- Provides initial biopile cost estimates
- User-friendly approach
- Produces on-screen and print copies of:
  - Installation cost sheet
  - O&M cost sheet
  - Summary cost sheet

Biopiles – Design & Construction

Overall Objective

To provide optimal conditions



Biopiles – Design & Construction

Predesign Decision

Temporary	Permanent
Existing foundation	New foundation
Minimal support facilities	Upgraded support facilities
Facility life < 5 yrs	Facility life > 5 yrs
Low capital cost	High capital cost

Biopiles – Design & Construction

Predesign: Site Selection

- Close-by utilities (electrical/water)
- Flat/solid ground (slight slope OK)
- Located outside 100 yr. flood plain
- Secured
- Outside of residential area
- Centralized site for soil handling
- Avoid off-base soil handling

Biopiles – Design & Construction

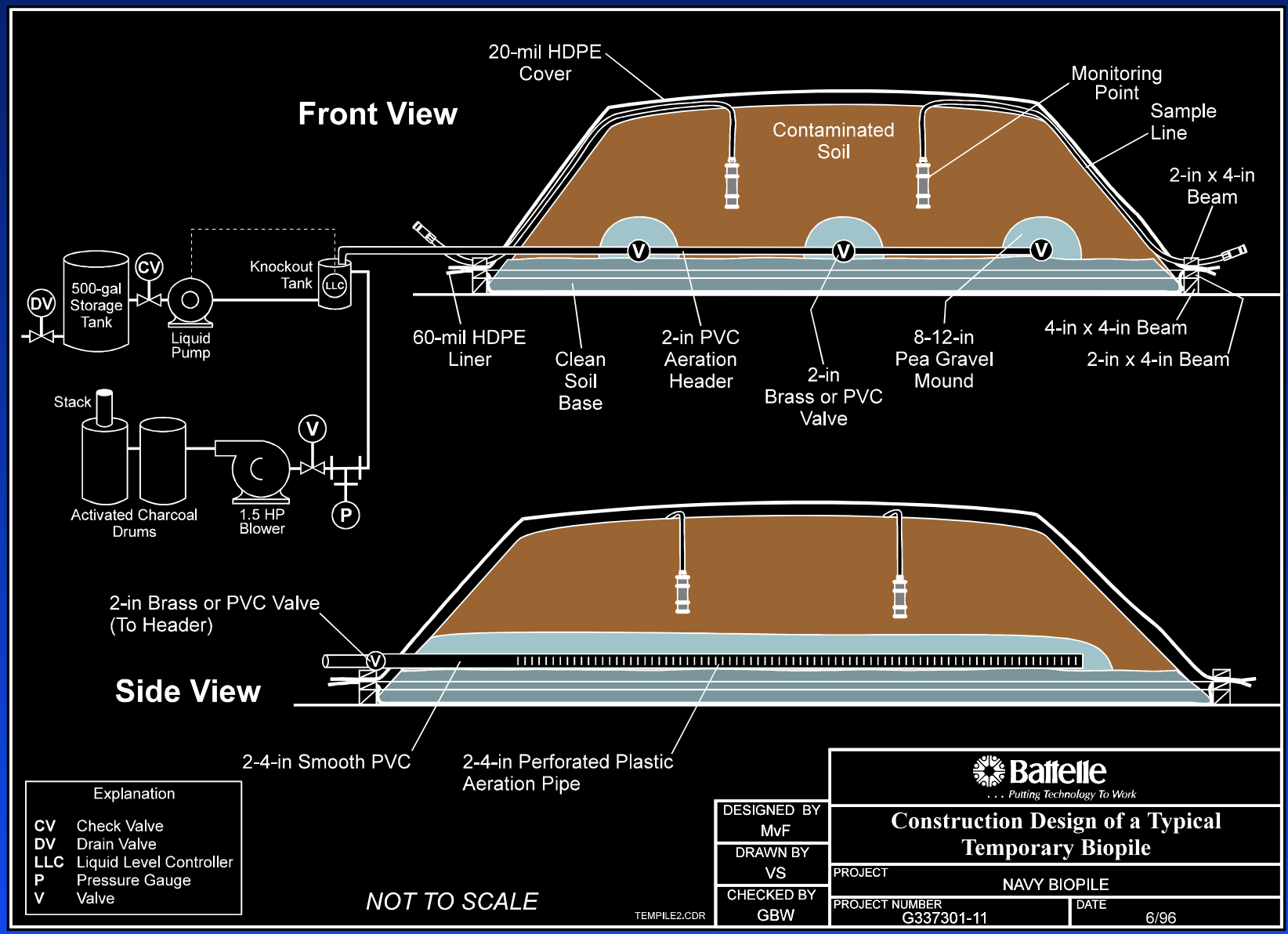
Predesign: Site Size

- Quantity of contaminated soil
- Frequency of reception
- Retention time in the biopile
- Soil preparation
- Additional space required for system equipment pads, soil storage and handling
- System size examples:
  - 500 yd^3 biopile: 11,000 ft^2
  - 3,000 yd^3 biopile: 40,000 ft^2

Biopiles – Design & Construction

Base Construction

- Soil or clay foundation/existing asphalt
- Impermeable liner (40-60-mil HDPE)
- Leachate collection berm
- Clean soil base


Front View
20-mil HDPE Cover
Monitoring Point
Sample Line
Contaminated Soil
2-in x 4-in Beam
Knockout Tank
LLC
CV
DV
500-gal Storage Tank
Liquid Pump
V
60-mil HDPE Liner
Clean Soil Base
2-in PVC Aeration Header
2-in Brass or PVC Valve
8-12-in Pea Gravel Mound
4-in x 4-in Beam
2-in x 4-in Beam
Stack
Activated Charcoal Drums
1.5 HP Blower
P
2-in Brass or PVC Valve (To Header)
Side View
2-4-in Smooth PVC
2-4-in Perforated Plastic Aeration Pipe
Explanation
CV Check Valve
DV Drain Valve
LLC Liquid Level Controller
P Pressure Gauge
V Valve
NOT TO SCALE
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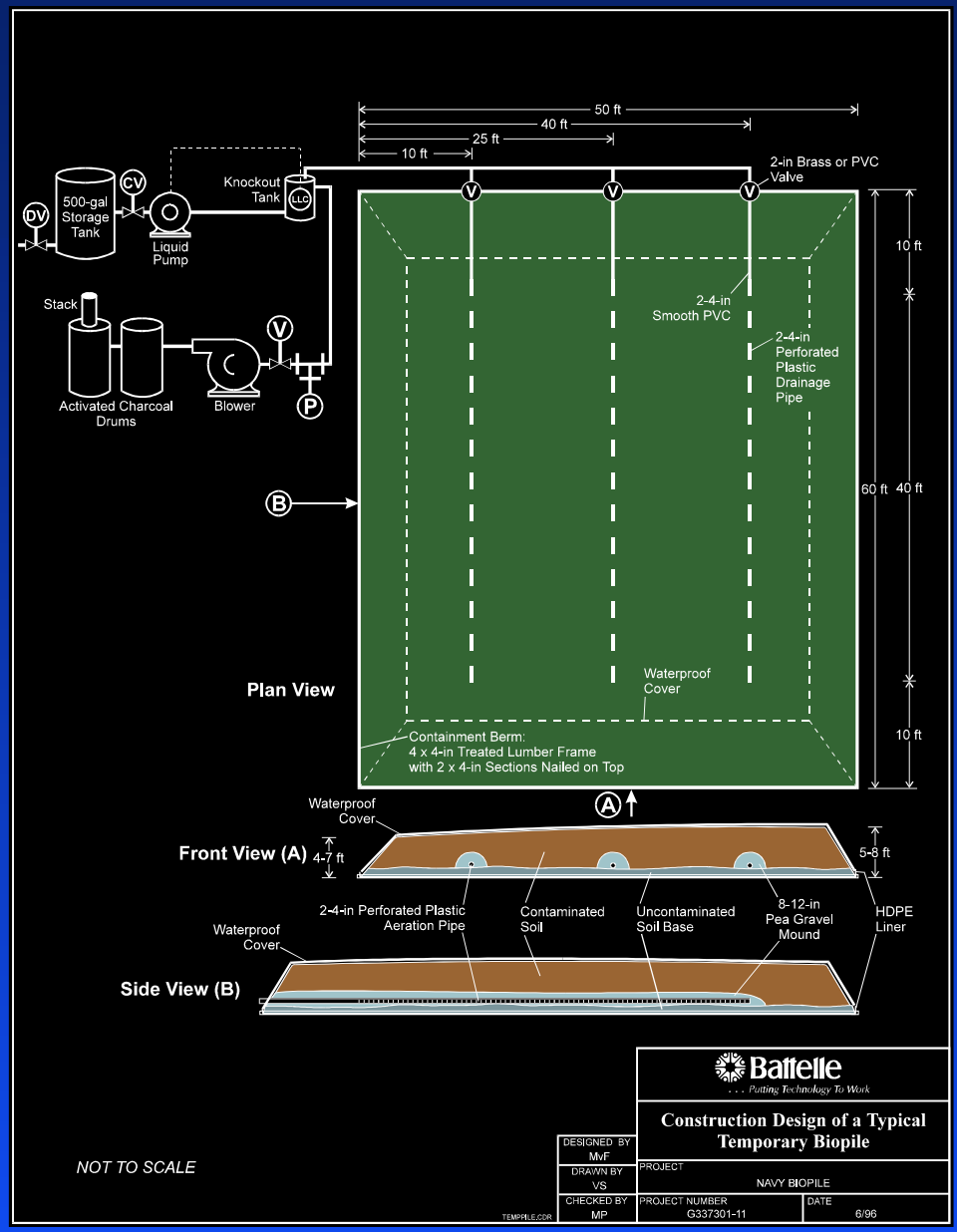
Construction Design of a Typical Temporary Biopile
DESIGNED BY MvF
DRAWN BY VS
CHECKED BY GBW
PROJECT NAVY BIOPILE
PROJECT NUMBER G337301-11
DATE 6/96


50 ft
40 ft
25 ft
10 ft
2-in Brass or PVC Valve
500-gal Storage Tank
CV
DV
Knockout Tank
LLC
Liquid Pump
Stack
Activated Charcoal Drums
Blower
V
P
B
2-4-in Smooth PVC
2-4-in Perforated Plastic Drainage Pipe
10 ft
60 ft
40 ft
10 ft
Plan View
Waterproof Cover
Containment Berm:
4 x 4-in Treated Lumber Frame
with 2 x 4-in Sections Nailed on Top
A
Waterproof Cover
Front View (A)
4-7 ft
5-8 ft
2-4-in Perforated Plastic Aeration Pipe
Contaminated Soil
Uncontaminated Soil Base
8-12-in Pea Gravel Mound
HDPE Liner
Waterproof Cover
Side View (B)
NOT TO SCALE
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Construction Design of a Typical Temporary Biopile
DESIGNED BY MvF
DRAWN BY VS
CHECKED BY MP
PROJECT NAVY BIOPILE
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TEMPPILE.CDR

Biopiles – Design & Construction

Aeration System

- Header pipe
- Valves at the manifold branch points
- Water knockout tank
- Cyclone separator
- Aeration pump
- Exhaust-gas treatment unit

Aeration System for a Temporary Biopile

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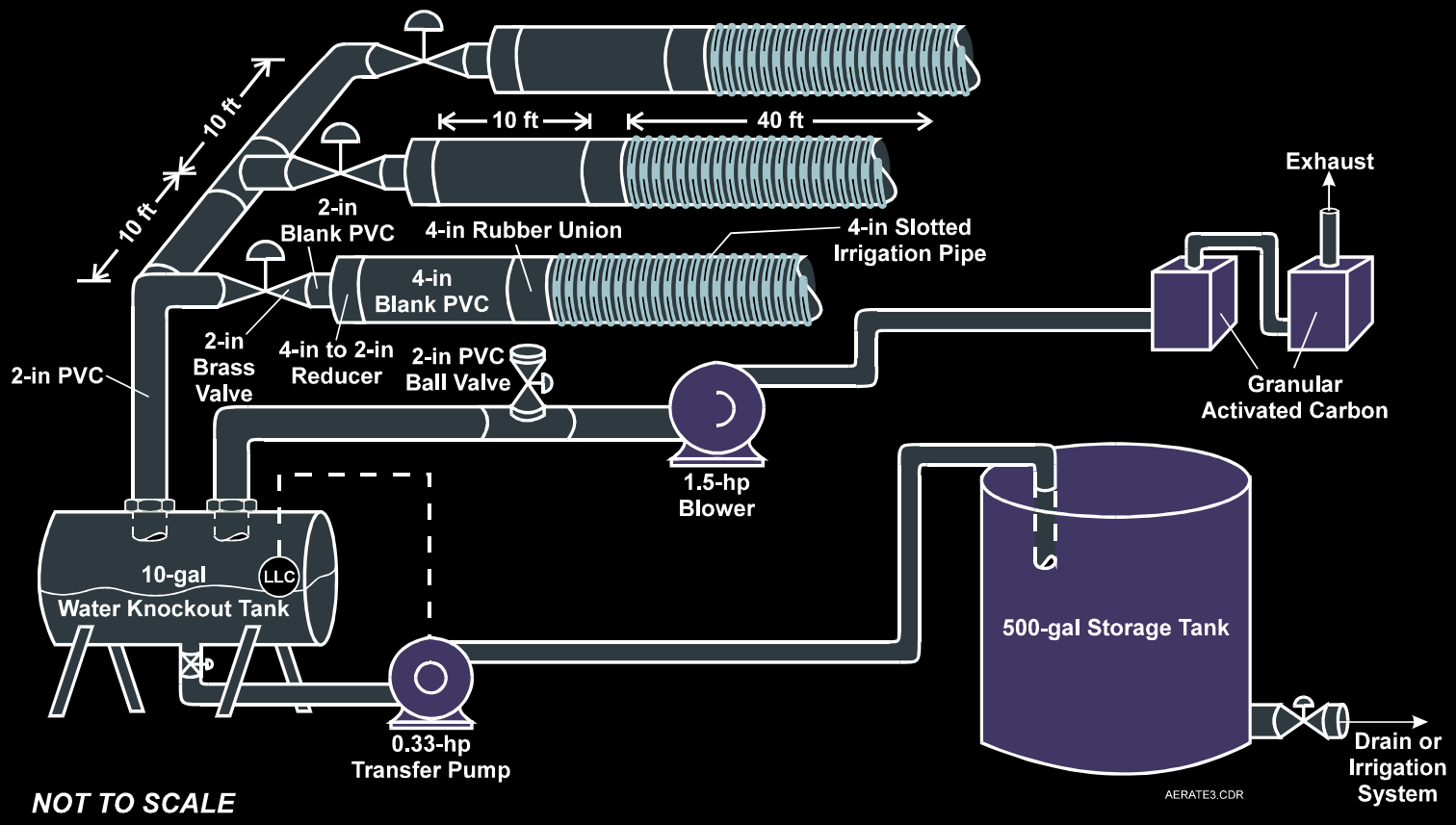

Biopiles – Design & Construction

Moisture & Nutrient System

- Initial moisture/nutrient addition during biopile formation
- Drip-line irrigation - climate considerations
- Leachate collection system (optional)

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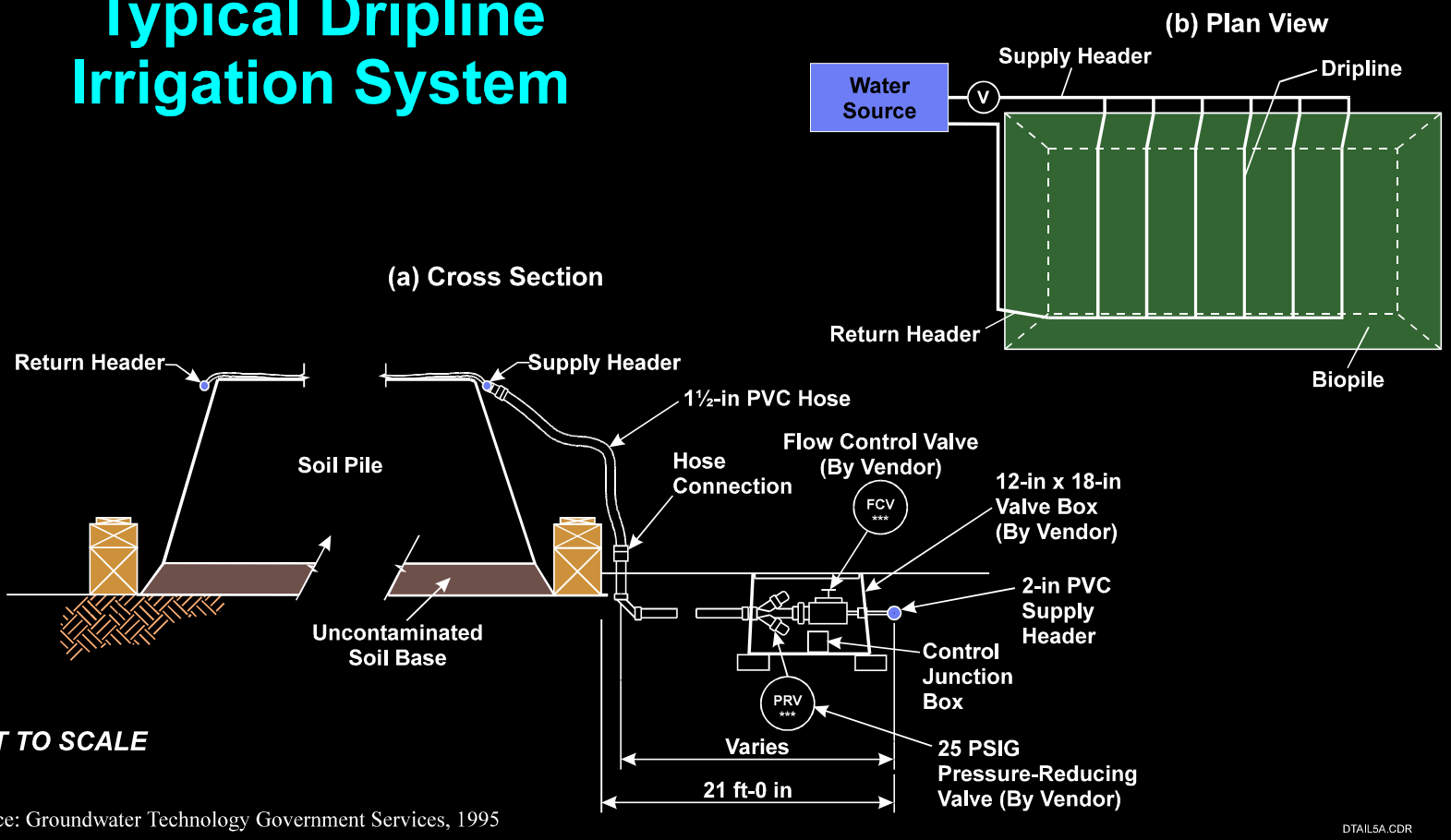
Typical Dripline Irrigation System



Source: Groundwater Technology Government Services, 1995

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Biopiles – Design & Construction

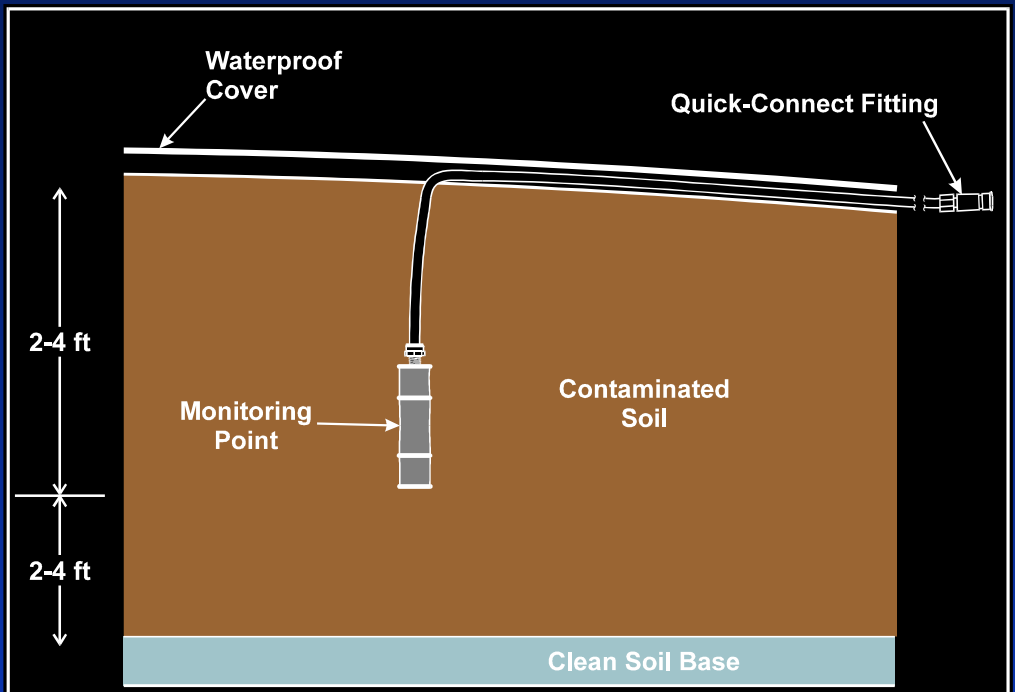
Biopile Formation

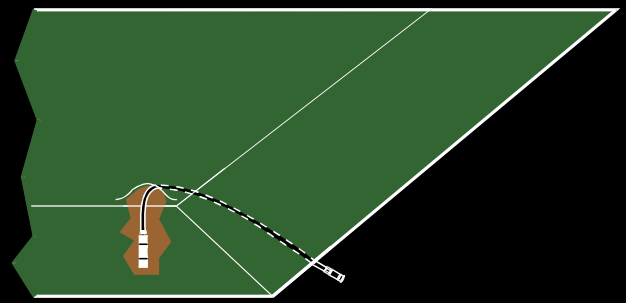
- Soil preparation/processing:
  - Bucket loader
  - Parallel bar screen
  - Trommel Screen
  - Soil shredder
  - Soil mixer

Biopiles – Design & Construction

Biopile Formation (cont.)

- Installing soil gas monitoring points
  - O_2, CO_2, TPH
  - Locations/depths
  - Thermocouples - temperature measurements





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Monitoring Point Emplacement Details

DESIGNED BY CC	PROJECT NAVY BIOPILE	
DRAWN BY VS		
CHECKED BY MvF	PROJECT NUMBER G337301-11	DATE 6/96

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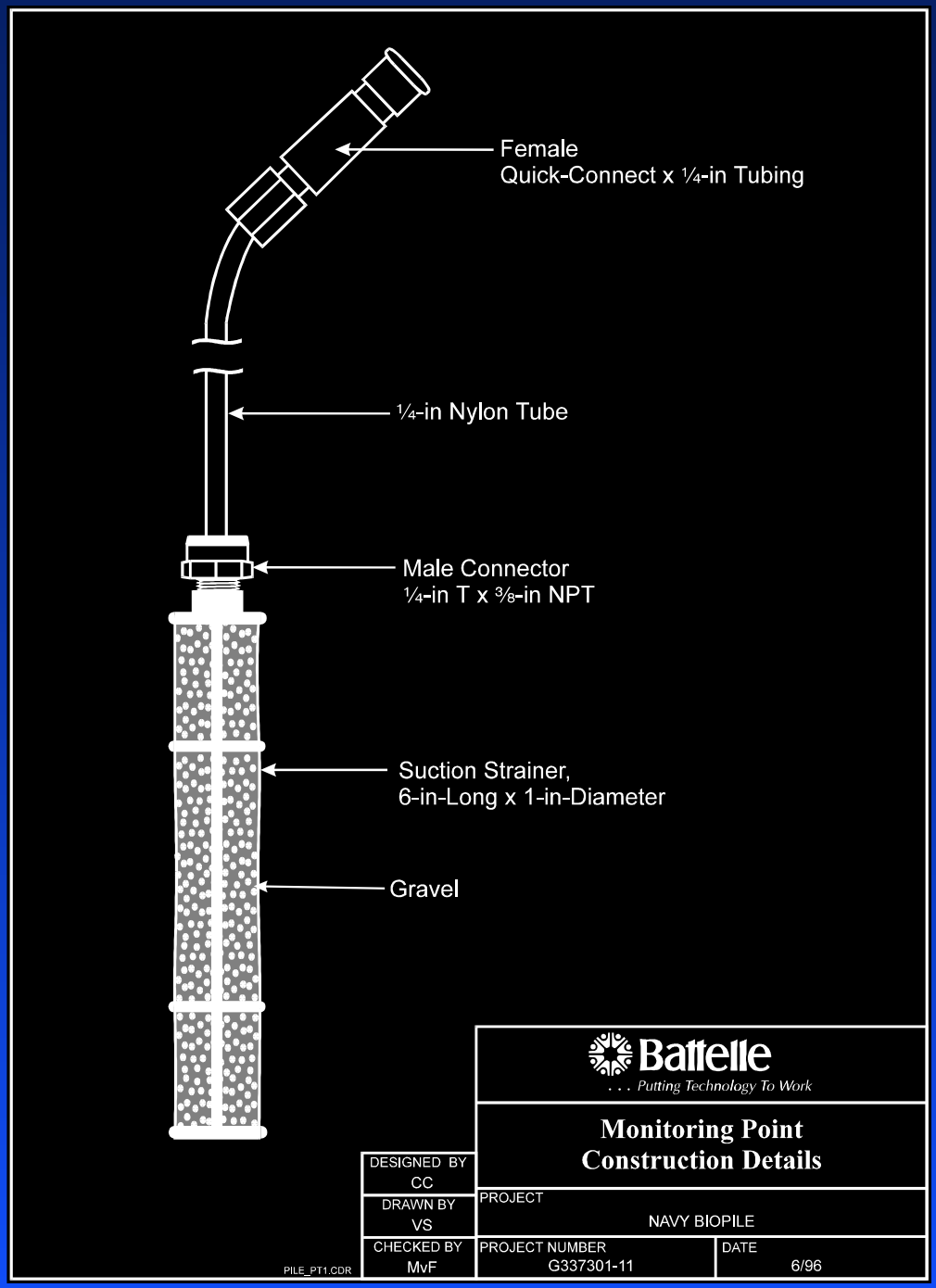
Female
Quick-Connect x ¼-in Tubing
¼-in Nylon Tube
Male Connector
¼-in T x ⅜-in NPT
Suction Strainer,
6-in-Long x 1-in-Diameter
Gravel
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Monitoring Point
Construction Details
DESIGNED BY
CC
DRAWN BY
VS
CHECKED BY
MvF
PROJECT
NAVY BIOPILE
PROJECT NUMBER
G337301-11
DATE
6/96
PILE_PT1.CDR

Biopiles – Design & Construction

Biopile Formation (cont.)

- Time-zero sampling
  - One soil sample per 50 yd^3 to 100 yd^3 (negotiable with regulatory agency)
  - Analyze typically for:
    - Initial TPH
    - BTEX
    - Moisture content
    - pH
    - Microbial density

Biopiles – Design & Construction

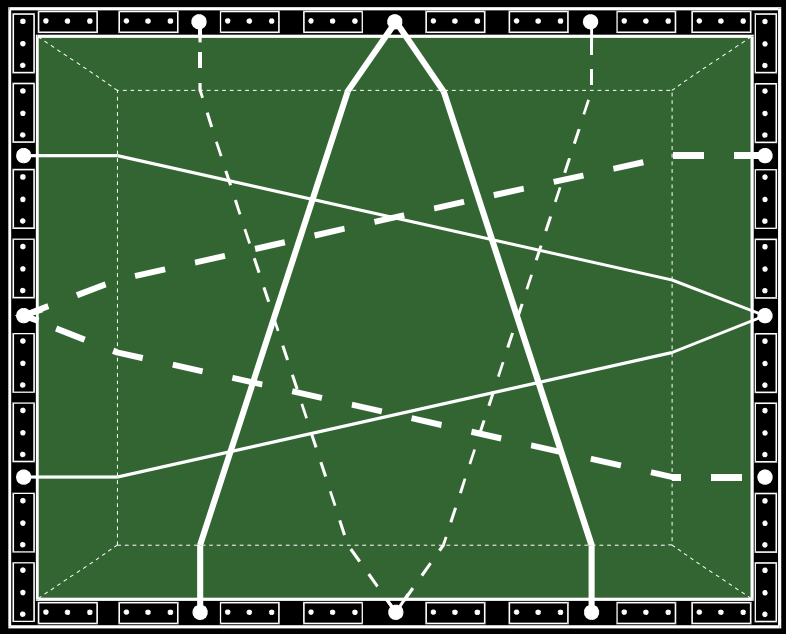
Biopile Formation (cont.)

- Soil gas sampling
  - Gas sample pulled from monitoring points
  - Soil gas readings:
    - O_2
    - CO_2
    - TPH
  - Establish effectiveness
  - Establish microbial activity (respiration test)

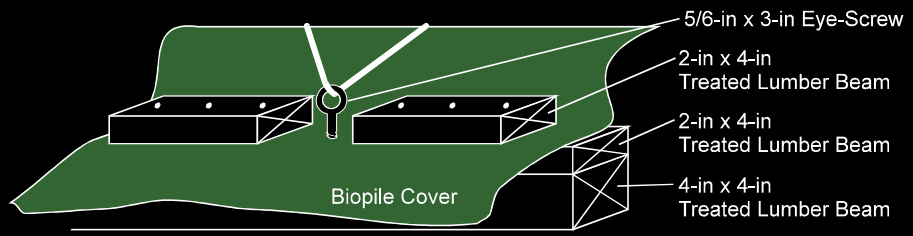
Biopiles – Design & Construction

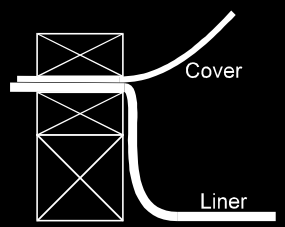
Biopile Formation (cont.)

- Cover installation
  - HDPE (12-20-mil thickness)
  - Black or other color (not clear)
  - Snug-fitting
  - Tied down



Recommended Cover Tie-Down Pattern Using Nylon Rope





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Biopile Cover Installation

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Biopiles – O & M

Operations Requirements

- Crew training & experience
- Operations management
- System startup & shakedown
- Routine Operations
- Off-gas treatment system operation

Biopiles – O & M

Maintenance Requirements

- Aeration manifold maintenance
- Biopile cover repair
- Blower maintenance
- Off-gas treatment system maintenance

Biopiles – O & M
Monitoring – Sample Schedule

Sampling Event	Sample Interval
Soil sampling	Upon pile construction and then as dictated by respiration test and soil-gas sampling
Soil gas sampling	At startup, 1 week after startup, and then monthly
Respiration testing (in-situ & shutdown respiration tests)	24 to 48 hours after turning on the blower, 1 week after initial test, and then monthly
Blower exhaust-gas sampling	Weekly or as dictated by the site
Exhaust-gas sample collection for laboratory analysis	Monthly

Biopiles – Videos

Biopiles: A Long-Term Solution

Biopiles – Case Histories

MCAGCC Twenty Nine Palms

- Design parameters
  - Size: 100 ft x 100 ft, 8 ft high
  - Capacity: 2,400 tons/cycle
  - Design specifics:
    - 12 in. sand layer
    - 60-mil HDPE liner
    - 1 ft pea gravel
    - 16 slotted PVC pipes (4-in-dia.)
    - Without cover

Biopiles – Case Histories

MCAGCC Twenty Nine Palms

- Contamination levels/Regulatory requirements
  - Typical start: 5,700 ppm TPH
  - Cleanup target level: 1000 ppm TPH
  - No air permit required
  - Treated soil used as daily landfill cover
  - JP-5 & some diesel

Biopiles – Case Histories

MCAGCC Twenty Nine Palms

- Special circumstances
  - 4 in. rain per year average - no cover
  - High winds
  - Desert southwest climate
  - Developed rapport with regulatory boards
  - Temporary converted to permanent

Biopiles – Case Histories

MCAS Yuma, AZ

- Design parameters
  - Size: 100 ft x 100 ft, 4 ft high
  - Capacity: 1,200 tons/cycle (4 cells, 300 tons/cell)
  - Design specifics:
    - 10 in. concrete
    - 60-mil HDPE liner
    - 4-ft-high wall
    - Special cover

Biopiles – Case Histories

MCAS Yuma, AZ

- Contamination levels/Regulatory requirements
  - Typical start: 30,000 - 50,000 ppm TPH
  - Cleanup target level: 5000 ppm TPH
  - No air permit required
  - JP-5

Biopiles – Case Histories

MCAS Yuma, AZ

- Special circumstances
  - Unique cover design
    - Water filtering
    - UV-resistant
  - Slotted lightweight flexible irrigation tubing, 4-in. dia. covered with nylon sleeves
  - Concrete poured over 2 in. slurry (unsaturated) placed over liner - concrete cracked, inadequate curing compound

Biopiles – Case Histories

National Test Site, Port Hueneme

- Design parameters
  - Size: 52 ft x 52 ft, 8 ft high
  - Capacity: 400 tons/cycle
  - Design specifics:
    - Existing asphalt base
    - 60-mil HDPE liner over felt pad covered by 8 to 12 in. soil to protect liner
    - 3- to 4-in. slotted PVC pipes covered by 6 in. pea gravel

Biopiles – Case Histories

National Test Site, Port Hueneme

- Contamination levels/Regulatory requirements
  - Typical start: 5,000 - 7,000 ppm TPH
  - Cleanup target level:
    - Gas: 100 ppm
    - Diesel: 250 ppm
    - Heavy petroleum: 1,000 ppm

Biopiles – Case Histories

National Test Site, Port Hueneme

- Special circumstances
  - Existing asphalt base
  - High profile SERDP site
  - Special monitoring
  - Special construction